UNIVERSIDADE DA BEIRA INTERIOR
Covilhã | Portugal

Voo à Vela em Altitude e Próximo de Montanhas

Efeitos Fisiológicos e Desempenho em Pilotos de Planador

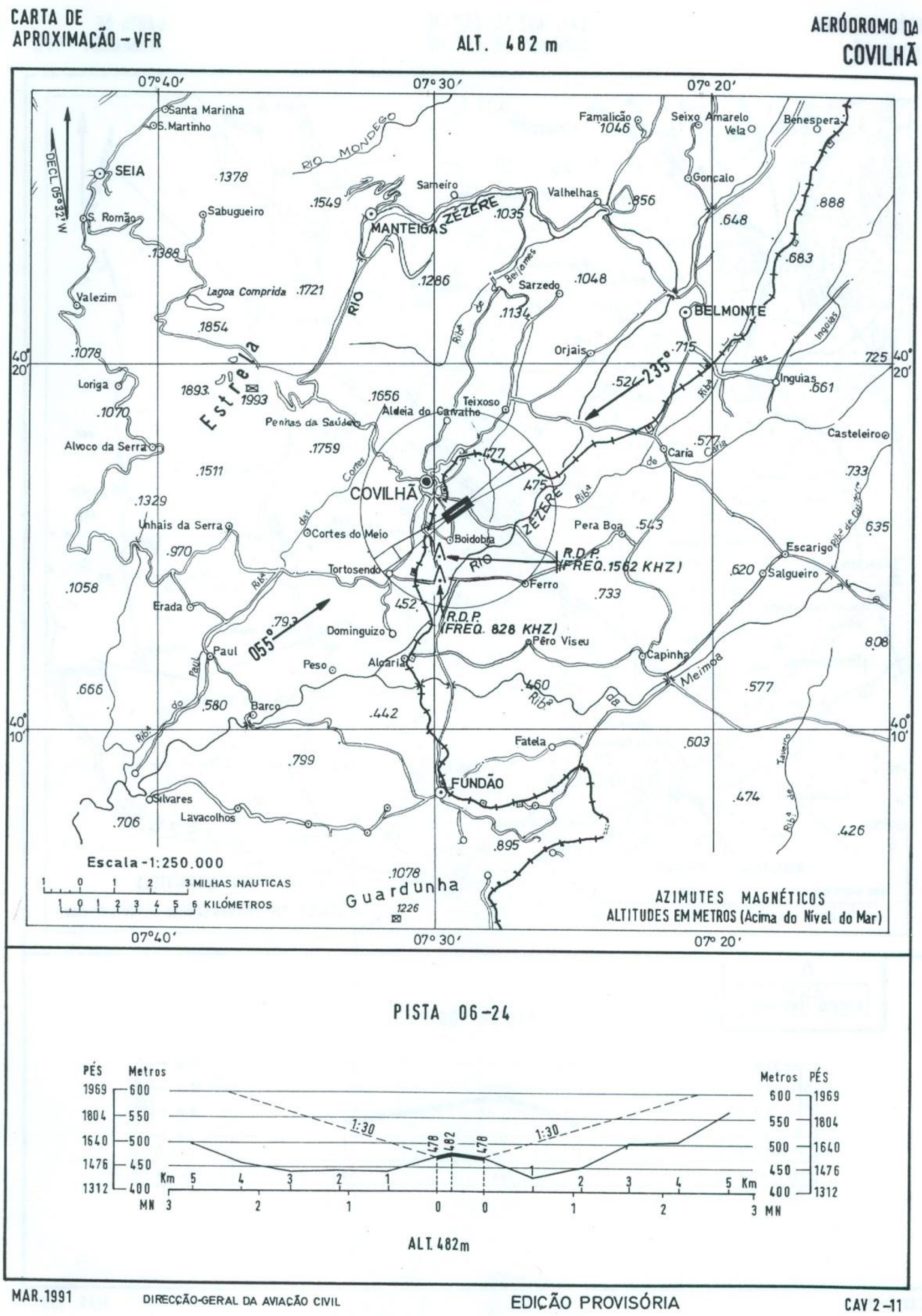
Tese de mestrado elaborada sob a orientação de:
Professor Doutor Jorge Miguel Reis Silva

Universidade da Beira Interior
Ana Fonseca

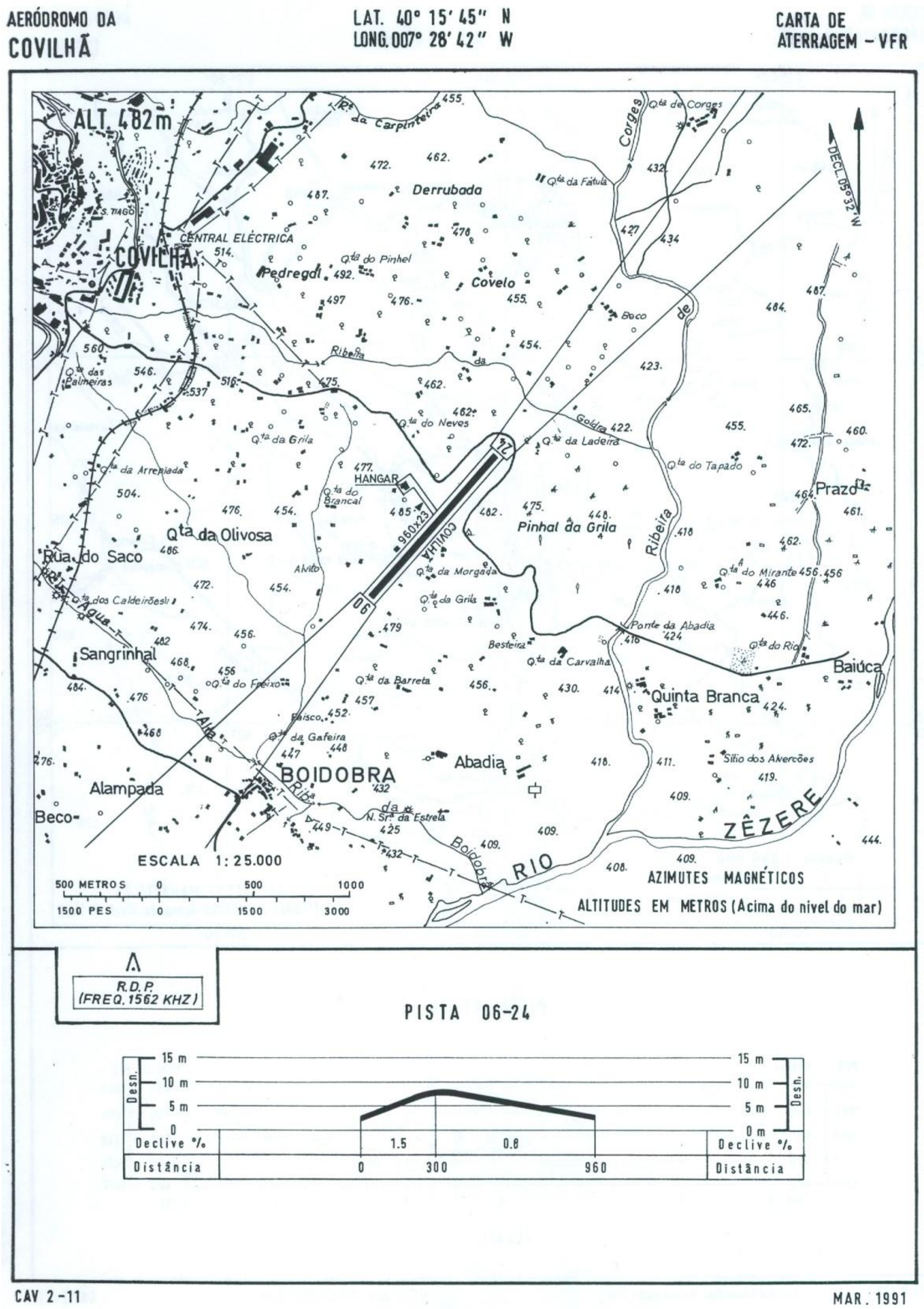
Outubro 2010

Anexo I

Cartas de Aproximação e de Aterragem Visual ao Aeródromo LPCV



Fonte: Manual do Piloto Civil, Direcção-Geral da Aviação Civil, Informação Aeronáutica, Portugal (2009).



Fonte: Manual do Piloto Civil, Direcção-Geral da Aviação Civil, Informação Aeronáutica, Portugal (2009).

Anexo II

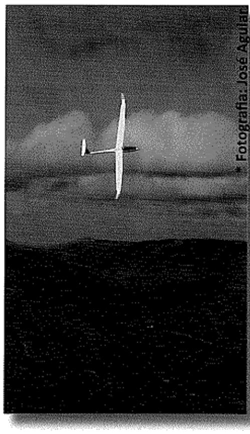
Artigo da Take Off
relacionado com o Voo à Vela na Covilhã

Voo à Vela, em Portugal

Desde muito cedo na história da Aviação, Portugal abraçou a causa do ar. Em 1909, era realizado o primeiro voo em planador, nos ares de uns terrenos próximos de Linda-a-pastora. Nascia de uma forma experimental e entusiasta, o Voo à Vela em Portugal.

EMMANUEL LOMBA - WWW.AIRLOMBA.NET

O Voo à Vela é a saudável "arte" de voar sem motor, disfrutando do ar na sua plenitude, gerindo energias, do início ao fim do voo, do início ao fim do dia... Actividade lúdica, desportiva, competitva ou até terapêutica, a prática do voo à vela assenta sobre a pilotagem de um planador.

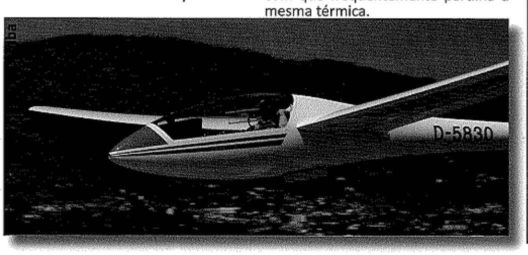


Fotografia: José Aguiar

O planador é um avião mono ou bilugar, (geralmente) sem motor, com uma configuração aerodinâmica que lhe permite percorrer distâncias maiores com menores perdas de altura (razão de planeio), relativamente aos outros aviões. Por exemplo, se, em ar estável, um C172 com motor parado consegue percorrer cerca de 8 metros de distância por cada metro de altitude que perde, um planador típico de instrução como o L-13 Blaník consegue percorrer 28 metros, nas mesmas condições. Outros planadores há com piores e melhores performances, sendo actualmente o Eta, o que "voa mais" com uma razão de planeio de cerca de 70:1. Note-se, no entanto, que a performance de um planador não é avaliada apenas por esta variável. Mas isto é assunto para outros artigos. A construção dos planadores, ao estilo da história da humanidade, atravessou várias eras: a era da madeira e a era do metal. Actualmente, atravessa a era dos materiais compósitos; mais leves, mais resistentes, mais... melhores! Hoje em dia, encontram-se a voar em Portugal planadores representativos destas três eras, como por exemplo o Schleicher Ka 6, o L-13 Blaník e o Duo Discus, respectivamente. Se um voo num avião ligeiro pode durar até cerca de três ou quatro horas em média, num planador, é comum voar-se até ao pôr do Sol. Em competição, os voos podem durar sete, oito ou mais horas. Neste sentido, o habitáculo de um planador deve ser tão confortável quanto possível. Se já experimentou sentarse a bordo do "15100" da Força Aérea Portuguesa, nalguma exposição, adorará sentar-se a bordo de um LS3 ou de um Duo Discus. O cockpit do planador pode ir desde o minimalista com os instrumentos mínimos, ao mais completo sistema electrónico de navegação, consoante os gostos e objectivos do proprietário. Em Portugal, foram já matriculados pouco mais de meia centena de planadores, porém, devido a razões técnicas ou burocráticas, só uma pequena parte continua sob um registo CS-Pxx e estima-se que destes, pouco mais de uma dezena estarão em estado de voo. O piloto de planador, para obter a respectiva licença de pilotagem, deve ter no mínimo 18 anos de idade e ter completado o curso de pilotagem e os exames teórico e prático. A duração de um curso é variável, pois depende de vários factores que vão desde a meteorologia à proficiência do aluno, passando pelas capacidades da escola. Se há países da Europa onde uma pessoa pode obter a sua licença em poucas semanas, em Portugal é comum demorar-se alguns meses. Aproveitase o inverno para as aulas teóricas e as Primavera e Verão para as aulas práticas. Portugal conta com pouco mais de setecentas licenças emitidas até hoje, e apesar de apenas uma minoria de pilotos ter a sua licença em dia (pouco mais de meia centena), um deles é octogenário! Com o lento crescimento do número de pilotos de planador, e para combater o envelhecimento da média etária destes, começam a aparecer movimentos promotores do Voo à Vela junto das camadas jovens da sociedade. Um exemplo disto é a associação Bicanca (ver enquadrado). Se o planador é o avião mais barato de voar, se é tão livre e relativamente tão ilimitado de operar, se proporciona tantas horas ininterruptas de prazer, porque é que não há mais Voo à Vela em Portugal? A resposta é tão complicada quanto a antropologia do povo português. Para começar, um planador não vai para o ar sozinho, com o seu piloto e eventual passageiro; começam aqui os "problemas"... Apesar de haver formas menos onerosas de lançar um planador para o ar, tal como o guincho, a catapulta ou o reboque com automóvel, por várias razões, em Portugal "prefere-se" o reboque por avião. Se neste tipo de lançamento, a desvantagem principal é o custo da operação do avião de

Emmanuel Lomba

reboque, a vantagem é que o mesmo leva o planador para onde este quiser. No caso do lançamento com guincho, muito popular no resto da Europa pelos seus baixos custos de operação, a operação deste tem de ser realizada por uma equipa de pessoas muito bem formadas/ treinadas e sobretudo altamente disciplinadas! O Voo à Vela, com o planador ainda no chão, é uma actividade de equipa, onde para que uns sintam o prazer de voar, outros têm de ter prazer em ajudar. Uma vez no ar, no local desejado, separado do seu rebocador, resta ao piloto disfrutar do ambiente em que se encontra, sendo uno com a sua máquina, livre como as cegonhas com que frequentemente partilha a mesma térmica.



Portugal, pela sua diversidade paisagística, oferece aos pilotos de planador todas as condições para a prática do Voo à Vela. (in)compreensivelmente, Portugal não é apenas paisagem mas também um sistema de coisas e pessoas que nem sempre contribuem para a actividade ao nível dos desejos de cada piloto. Porém, de norte a sul do país, e.g., em Bragança, Covilhã ou Évora, entre outros locais, é possível efectuar voos que vão desde os locais "sobe e desce", térmicos ou orográficos aos avançados crosscountry.

Se por um lado existe o "sobe e desce", também conhecido como "voo para grávidas", que é normalmente feito sobre aeródromos como o de S. Jacinto, que pela sua proximidade com o mar não é propício ao aparecimento de térmicas para o prolongamento temporal do voo. Por outro lado, a Covilhã que está a tornar-se na "meca" do Voo à Vela em Portugal agrupa na sua envolvência as condições necessárias tanto para o voo orográfico quanto para o voo térmico. Em dias especiais, é também possível praticar o voo em onda. Ainda no solo, o piloto vai preparando o seu planador sem perder de vista a evolução da meteorologia. Com o passar do tempo, começa mentalmente a esboçar o voo que vai fazer. Já no ar, apalpando este, sentindo as correntes, gerindo as energias, decide se vai mais longe, até ali sobre a Torre ou até acolá à vizinha Espanha. De volta à terra firme, limpa e arruma a sua gloriosa máquina enquanto o seu espírito ainda está por aterrar.

voo à vela bicanca

O „Projecto Bicanca" constitui, sob a forma de uma associação sem fins lucrativos, numa iniciativa com vista à dinamização do voo à vela entre os jovens, possibilitando o conhecimento deste desporto e a partilha da experiência do voo entre eles e, dentro das possibilidades financeiras que se venham a conseguir reunir, o apoio na obtenção da licença de voo. Esta associação, é também responsável pela organização de diversos workshops sobre diversas áreas do voo à vela. No passado dia 20 de Março, ocorreu em Coimbra um seminário sobre cross-country que reuniu durante todo o dia pilotos de todo o país.

www.bicanca.vooavela.org

Anexo III

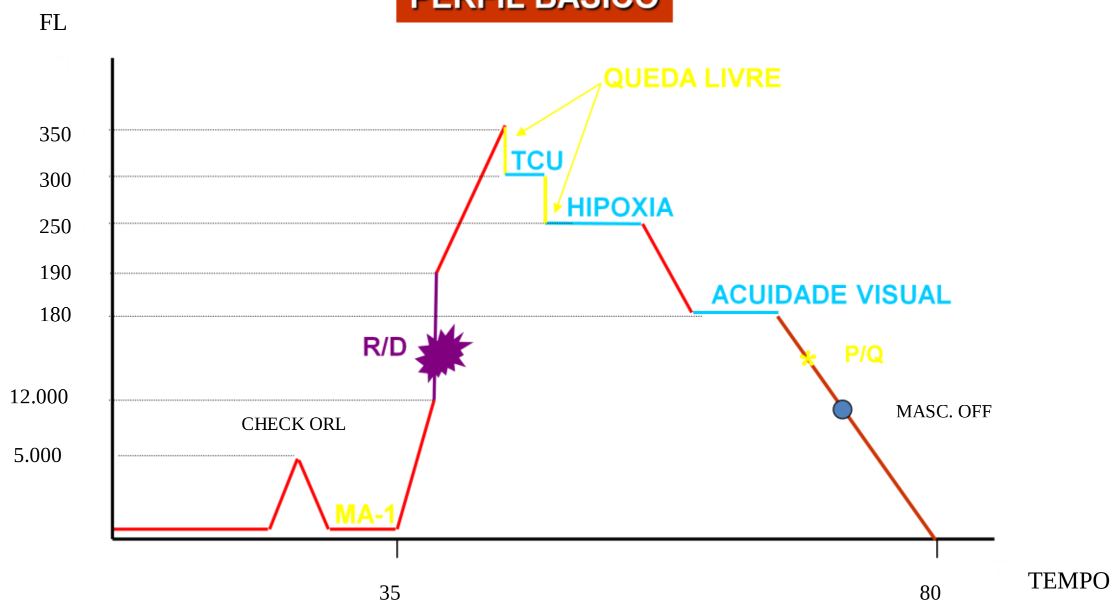
Perfis de Voo – STV (FAP)

Câmara Hipobárica - FAP

Fonte: http://www.revistamilitar.pt/modules/articles/article.php?id=120

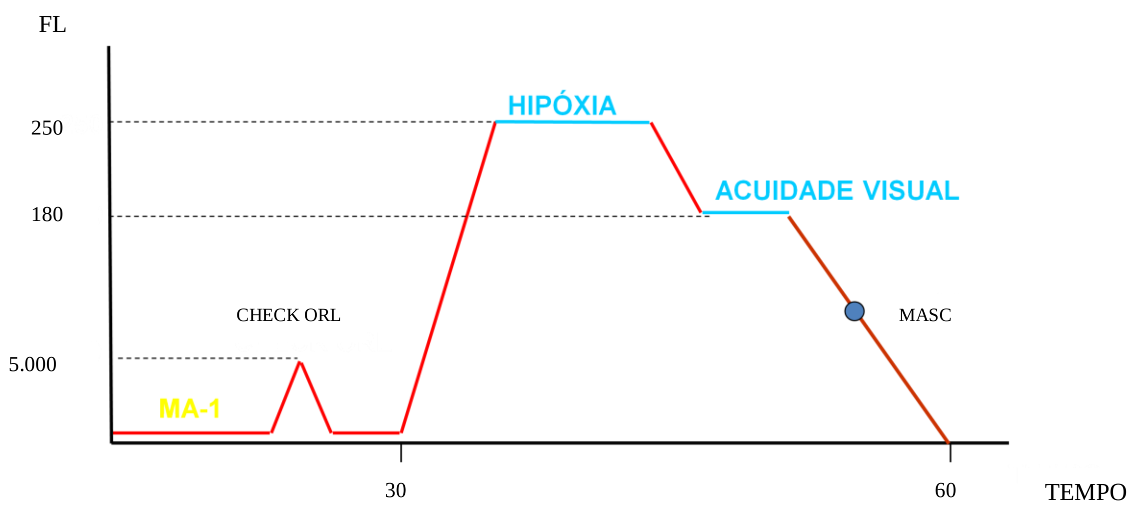
SECÇÃO DE TREINO FISIOLÓGICO

PERFIL BÁSICO



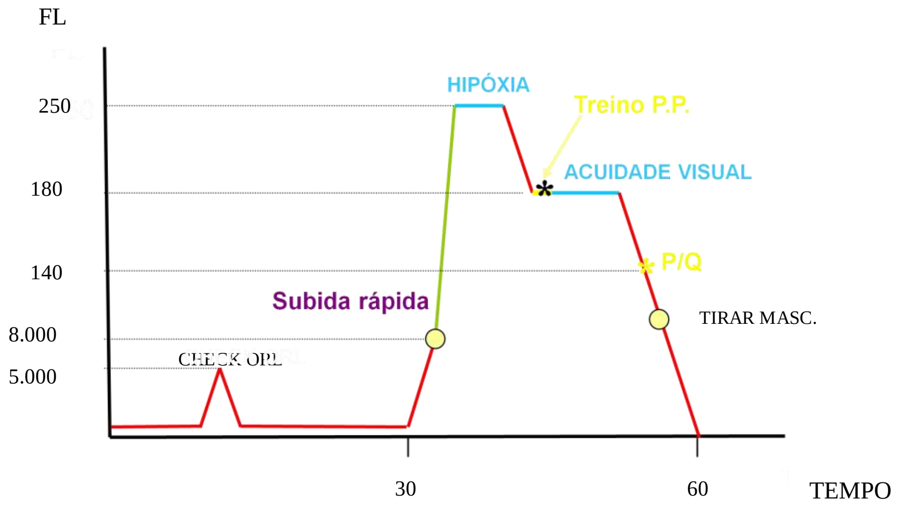
SECÇÃO DE TREINO FISIOLÓGICO

PERFIL REFRESCAMENTO TRANSP/HELIS



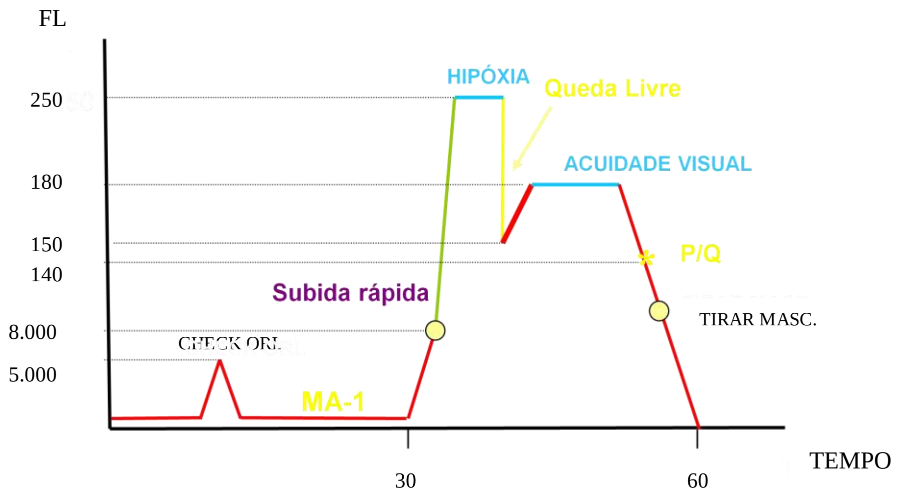
SECÇÃO DE TREINO FISIOLÓGICO

PERFIL REFRESCAMENTO CAÇAS



SECÇÃO DE TREINO FISIOLÓGICO

PERFIL REFRESCAMENTO SOGAS



Anexo IV

Artigo Científico apresentado e publicado na 14ª Conferência da ATRS

PHYSIOLOGICAL EFFECTS AND GLIDER PILOT'S PERFORMANCE. THE CASE FOR GLIDING ACTIVITY IN ALTITUDE AND NEAR THE MOUNTAINS (SERRA DA ESTRELA, COVILHÃ)

Ana Fonseca and Jorge Silva
Aerospace Sciences Department
Beira Interior University, Covilhã, Portugal
+ 351 275 329 732; + 351 275 329 768
ana_b_fonseca@hotmail.com and jmiguel@ubi.pt

ABSTRACT

Flying in general, and gliding (soaring) in particular, requires high levels of concentration which may be affected by physiological symptoms of the pilot. This is mainly relevant if the glider activity is developed near natural obstacles as, for example, the mountains.

Flying all around mountains, i.e., in altitude, means quite always the danger of oxygen deprivation, mainly if the pilots have no time enough to feel, or recognize, the symptoms of hypoxia, which may affect his own performance augmenting therefore the probability of an accident.

The purpose of this work is to study the linkage between physiological effects and glider pilot's performance, mainly when flights are in altitude and near mountains, where to know in advantage those effects may be crucial to ensure the safety of flights.

We developed this work at Covilhã, near Serra da Estrela, where there are both very good conditions for gliding (soaring) and a growing community of glider pilots. Following some recommendations from the state of the art review we installed aboard medical equipment and video cameras to determine precisely the correlation between physiological parameters and flight performance of pilots.

Key words: Physiological Effects, Pilot's Performance, Gliding Activity in Altitude near Mountains

1. INTRODUCTION

The Federal Aviation Administration (FAA) defines a glider as a heavier-than-air aircraft that is supported in flight by the dynamic reaction of the air against its lifting surfaces, and whose free flight does not depend on an engine [1].

To remain in the air for quite some time gliders require rising air to help them climb because otherwise after release the towable aircraft they start fallen to the ground due to gravity. Thus, there are three classic ways to fly without engine:

- Thermal soaring (Figure 1);
- Slope or ridge soaring (Figure 2);
- Wave soaring (Figure 3).

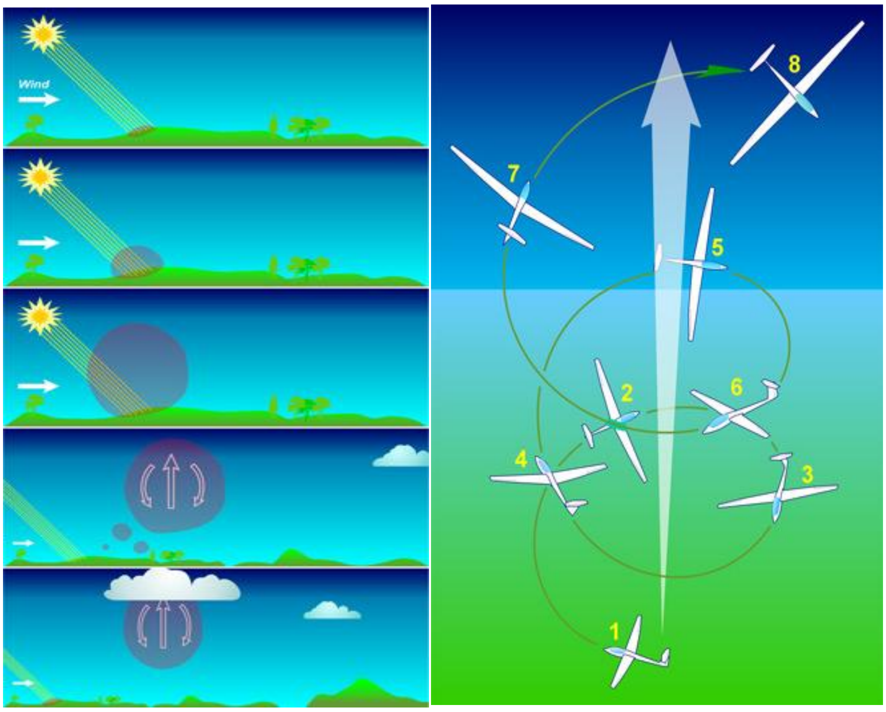


Figure 1: Thermal soaring [1]

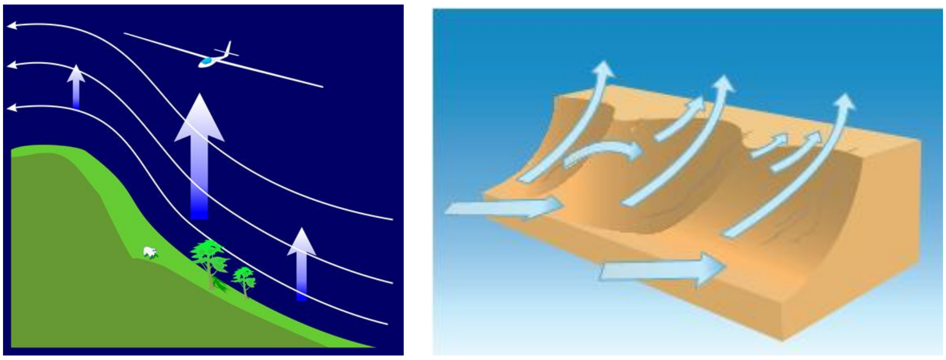


Figure 2: Slope or ridge soaring [1]

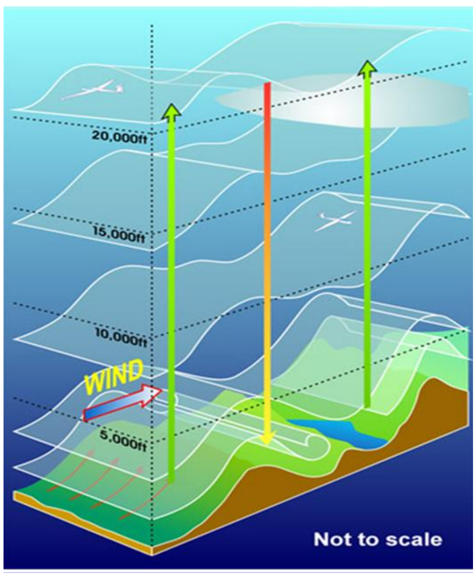


Figure 3: Wave soaring [1]

In Portugal there are no currently many pilots practicing gliding but is now starting to notice a growing interest in this activity. In the case of the zone of Serra da Estrela in general and in particular of Covilhã, there are conditions to fly both in thermal soaring and in slope or ridge soaring or in wave soaring, as we shall see in due course.

Despite all the developments in technology to improve safety flight there is a factor that remains the same - the human factor. Through a broader perspective, the term "human factor" describes the cause of some accidents / incidents, but usually they occur not only due to a single decision or event but rather due to a chain of events triggered by a number of factors (Figure 4).

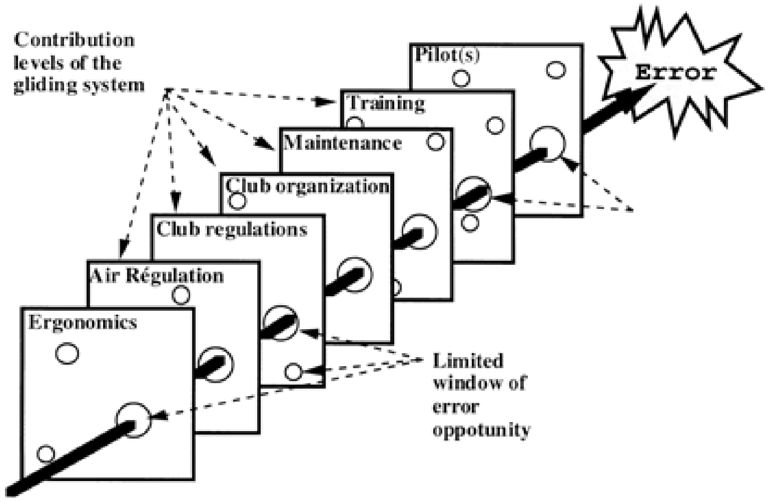


Figure 4: The model of James Reason [2]

It has been estimated that 65% of accidents involving gliders were due to human factors. Thus, it can be concluded that fly in general and gliding in particular, requires intense concentration and responsibility.

A number of physiological effects can be linked to flying. Some are minor, while others are important enough to require special attention to ensure safety of flight. In some cases, physiological factors can lead to in-flight emergencies. Some important medical factors that can affect glider pilot are: hypoxia, hyperventilation, middle ear and sinus problems, spatial disorientation, motion sickness, carbon monoxide poisoning, stress and fatigue, dehydration and heatstroke, alcohol and drugs, and decompression sickness [1]. For example, the medical factor Hypoxia occurs when there is an inadequate supply of oxygen necessary for normal functioning of the human body. The forms of hypoxia can be divided into four different groups based on their cause, that is: hypoxic hypoxia (due to the reduced partial pressure of oxygen at altitude); hypemic hypoxia (when the blood is not able to carry a sufficient amount of oxygen to the cells of the body due to, for example, situations of anemia, blood loss due to a donation, or by carbon monoxide poisoning); stagnant hypoxia (poor blood circulation caused by, for example, a heart problem, a shock or a blocked artery, or may also be the result of many G's positive or low temperatures that result in the reduction of blood flow and difficulty of irrigation of the extremities of the body); and histotoxic hypoxia (inability of the cells to effectively use oxygen. This impairment of cellular respiration can be caused by alcohol and other drugs, such as narcotics and poisons). The symptoms of hypoxia vary with the individual but the common symptoms are:

- Headache;
- Decreased Reaction Time;
- Impaired Judgment;
- Euphoria;
- Visual Impairment;
- Drowsiness;
- Lightheaded or Dizzy Sensation;
- Tingling in Fingers and Toes;
- Numbness;
- Blue Fingernails and Lips (Cyanosis);
- Limp Muscles.

2. LITERATURE REVIEW

Currently, although the gliding is already a category for recreational aircraft ancient, many studies haven't yet been carried out taking into consideration the safety of the pilots. In Portugal, only in military aviation is given enough importance to the medical factors; in civil aviation only during the course of the pilot is taught, on some hours of lectures, the medical factors that can implicate the safety but in practice there isn't any specific training. Thus, and as the currently community of civilian pilots has been increasing (flying for leisure mainly at weekends), we think it is extremely important to study the conditions under which the sport is practiced and raise awareness among the pilots about the safety associated with it.

Some of the articles studied in the beginning of the study were the follows:

✓ "*Glider accidents in France from 1989 to 1993: the role of the pilot*" [2]

The purpose of this paper is to give a picture of glider accidents in France from 1989-1993: 255 typical accidents were analysed in the light of recent developments in cognitive psychology. It is shown how Human Factors in aeronautics can explain glider accidents: each accident is considered as an event resulting from an error linked to a cognitive process, frequently linked to particular causes. 255 criteria (type of flight, injuries, damage, pilot experience, type of errors, etc.) are compared as causal factors of the accident. Several suggestions are made with the hope of increasing the safety of soaring flight.

✓ "*Algumas notas sobre o voo de montanha – o testemunho de um neófito.*" [3]

António Vieira Conde wrote this article after doing mountain flights in Covilhã in double command with José Aguiar. According to him, the basic rules of flying with safety are as follows:

- You can not fly in the mountains for "attitude" (as opposed to what happens in the plain), because there is no horizon line as a reference;
- The pilot must be always aware of the wind direction because the wind direction at the surface is not necessarily what is observed at high altitude;
- The pilot should never go to the other side of the ridge of the mountain where it flying because going there without a security height it could lead to being "sucked" by a descendant;

- The technique of in-flight climb mountain advises that one must fly along the ridge of the mountain enjoying the ascendant;
- In the Serra da Estrela, on the side of the hill which is facing the east (Covilhã), the flight must be done by "levels" / "steps", whose security height depends on the wind and the turbulence. In this area we find three levels of progression: 1º- “Varanda dos Carquejais / Sanatório”, 2º- “ Penhas da Saúde / Lago Viriato”, e 3º- “Torre”.

✓ “*Renascido a 24 de Abril?*” [4]

António Mota reported in the 1st person an accident on he was victim. The accident was on 4/24/2003 on the mountain (Serra da Estrela). The glider on he was flying was a PW5 (CS-PBN / "C3") which become totally destroyed but fortunately it only resulted in minor abrasions to him.
According to António Mota dangers of gliding are on all sides! Thinks so basically due to two factors. There are dangers in just three classical forms of glide and because it happens in Portugal (as in many other countries) that in *PP ab-initio* courses the pilots are only trained to fly in thermal soaring.
In case of the accident that he was involved, António Mota, decided to try to fly alone in slope or ridge soaring despite their 150 hours of experience in flying gliders were all in thermal flight.

✓ “*Looking for an accident: glider pilots’ visual management and potentially dangerous final turns.*” [5]

Accidents caused by spinning from low turns continue to kill glider pilots despite the introduction of specific exercises aimed at increasing pilot awareness and recognition of this issue. In-cockpit video cameras were used to analyze flying accuracy and log the areas of visual interest of 36 qualified glider pilots performing final turns in a training glider. Pilots were found to divide their attention between four areas of interest: the view directly ahead; the landing area (right); the airspeed indicator; and an area between the direct ahead view and the landing area. The mean fixation rate was 85 shifts per minute. Significant correlations were found between over-use of rudder and a lack of attention to the view ahead, as well as between the overall fixation rate and poorer coordination in the turn. The results provide some evidence that a relationship exists between pilots' visual management and making turns in a potentially dangerous manner. Pilots who monitor the view ahead for reasonable periods during the final turn while not allowing their scan to become over-busy are those who are most likely to prevent a potential spin.

✓ “*Gliding Aviation Medicine, High Altitude Aspects and Mountain Wave Project 1999*” [6]

Mountain Wave Project 99, in Argentina, was a scientific Hi-Tec first time high altitude wave glider-flying excursion. To make the study two groups of about 15 experienced pilots (accompanied by three high performance motor-gliders: a two-seat Stemme SV 10, an ASH 25 M and a Nimbus 4M), supported by the Argentine pilots, performed more than 100 flights, totaling hundreds of flight hours and sometimes over long distances of more than 1800 kilometers, setting

some world records. In this project were involved several areas of knowledge and between these, medical factors were one of the most demanding. In summary, some of the tasks undertaken in this project were:
- Flying at altitudes above 3,000 meters (10,000 feet) in gliders requires special attention to medical factors such as, for example, hypoxia;
- Wave Flying at altitudes above 6000 m / 20 000 ft requires special high altitude preparations;
- High altitude scientific literature studies, basic instruction and hypobaric chamber training were performed;
- Technical planning, O_2 requirement calculation and emergency training had to be done;
- Were tested and used two systems of oxygen supply to pilots (EDS & Bendix) because at altitudes below the EDS oxygen system provides enough O_2, but the functionality of the battery must be monitored closely;
- Hypothermia, Hypoxia, Hyperventilation and DCS (Decompression Sickness) are the physiological threats.
The flight safety and altitude physiology rules were known due to prior intensive basic training and thus all flight safety related concepts were key elements for the success of MWP 99.

- ✓ "*Practical Preventive Measures and Treatment of DCS (Decompression Sickness) in High Altitude - Glider Flying above 22.000 ft / 6.000 m*" [7]

According to Juergen Knueppel, the glider pilots who fly above 20,000 feet (6,000 m) should know the basics of the Law of the Henry gas, in order to be prepared to fight the decompression sickness (DCS). Scientific knowledge is still in development, however, at the outset several empirical limits must be respected to avoid possible disastrous consequences for health (including the death of pilots). Decompression sickness leads to the formation of nitrogen bubbles in the human body, and there are two main types of symptoms of DCS that should be differentiated:
- Type I: Symptoms are mainly severe pain in joints, leading to the pilot to fold onto itself;
- Type II: The symptoms are neurological in nature such as the brain and nerve dysfunction. Such symptoms are considered serious.
The first-aid after the first symptoms of decompression sickness are: Apply 100% oxygen; hydrate by drinking isotonic solutions (water with ⅓ of apple juice and / or ½ teaspoon of salt) and take the patient into a hyperbaric chamber for 2-5 hours. According to Juergen Knueppel a rule to follow is that no pilot shall perform any flight the next day to perform a high altitude where they had occurred and symptoms of DCS.

- ✓ "*The Perlan Project*" [8]

The Perlan project is divided into three phases:
- Phase 1 consists in soaring to the stratosphere using mountain wave and the Polar Vortex. A glider (DG505M) was used to do this phase and the pilot used full pressure suits because the cockpit of this glider is unpressurized.
In Omarama (New Zealand) and El Calafate (Argentina), on August 30th, 2006, with the pilots Steve Fossett and Einar Enevoldson was set a world-record

altitude for gliders of 50,671 feet (15,447 m). Measurements taken during the flight proved that they had reached the stratosphere. This has provided the team with valuable information that will be used in Phase 2;

- Phase 2 consists to soar to 90,000 feet using stratospheric mountain waves and the Polar Vortex. This phase requires a special pressurized high altitude glider to be built. The location will be where the previous record was set (El Calafate, Argentina). This phase will be on August-September 2011;

- Phase 3 have the goal to soar to 100,000 feet and carry out long international flights using the Polar Vortex. The location, the time and the glider is still undetermined.

3. GLIDING AROUND COVILHÃ

As we can see in the following Figures 5-7, the area of Covilhã, has excellent weather and topographical conditions that allow gliding. As we can see in the Figure 7 the prevailing wind in this region facilitates the formation of updrafts that will enable the three classical forms of soaring (in thermal, slope or ridge and in wave).

Figure 5: Map with the location (A) of Covilhã [9]

Figure 6: Topography of the region of Covilhã and Serra da Estrela [9]

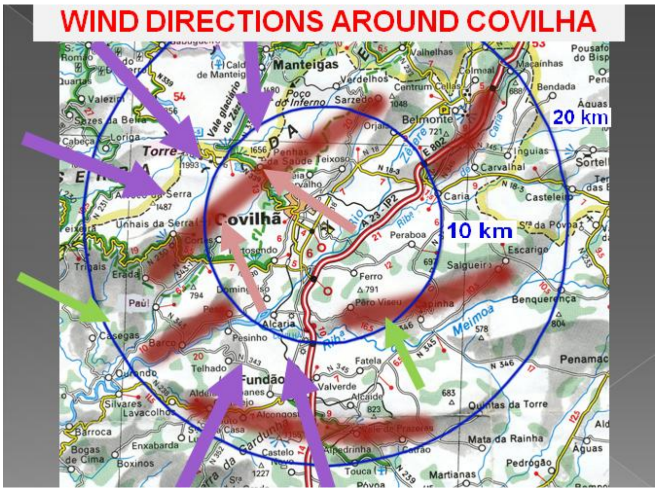


Figure 7: Wind directions around the region of Covilhã (curves in red = mountain areas) [10]

Moreover, it is also possible to check through the images of clouds of Figures 8 and 9, the likelihood of rising air in the region of Covilhã is high.


Figure 8: *Lenticular* clouds in Covilhã [10]

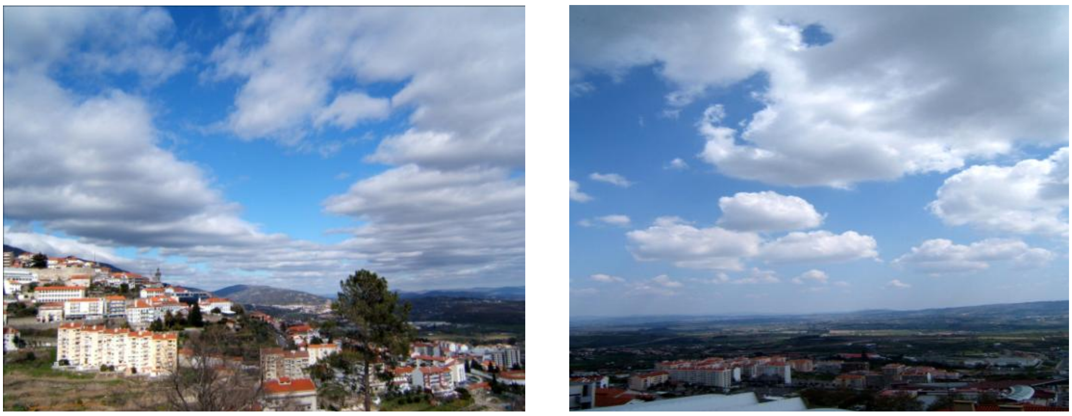


Figure 9: *Cumulus* clouds in Covilhã [10]

Besides the good weather that Covilhã have for the practice of gliding, this city also has an aerodrome (Figure 10) with two runways from which are now becoming increasingly towed gliders during the weekends. As well as air traffic in the region is very small it can be concluded that this is a "good bet" for the development and growth of the practice of gliding in Portugal!

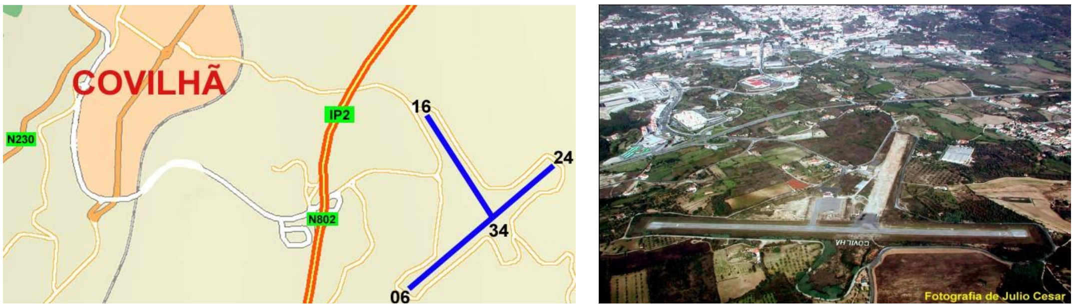


Figure 10: Covilhã Airfield (LPCV) [11]

4. CONCLUSIONS / FUTURE CHALLENGES

Since Covilhã is one of the major places of interest for gliding in Portugal (due to, among other things, the excellent topographical conditions), it is important to study the physiological factors in gliders pilots for each pilot may know the own physical limits when flying at altitudes higher than those obtained in thermal soaring. The study we are developing is intended to understand the symptoms of lack of oxygen in the blood (hypoxia) during flight in gliders. We know in theory that hypoxia causes: headache, decreased of the reaction time, euphoria, etc., and with this study we want to evaluate if in real time these symptoms will affect the performance of the glider pilots in flight in the region of Covilhã.

To reach this we are developing and carry out calibrations of medical equipment (like the one showed on the Figure 11) provided by the Faculty of Health Sciences at University of Beira Interior, which are being used to obtain preliminary results.


Figure 11: Pulse Oximeter [12]

The results obtained so far have been very satisfactory and we hope soon to get more results in the following three areas:

- Clinical recommendations for future practitioners of this sport, especially when flying in mountain;
- Recommendations to flight equipment manufacturers to raise their awareness of the need to install on board equipments of early and real-time diagnosis of the performance/physiology of the pilot;
- Recommendations to the regulator, to introduce in legislation the appropriate mechanisms to make the practice of gliding more safely.

REFERENCES

[1] Federal Aviation Administration, "*Glider Flying Handbook*", New York: Aviation Supplies and Academics Inc, 2003.
[2] Caron, F., "*Glider accidents in France from 1989 to 1993: the role of the pilot*", Université René Descartes, Paris, France, 1997.
[3] Conde, A. V., "*Algumas notas sobre o voo de montanha – o testemunho de um neófito*", Covilhã, Portugal, 2009.
[4] Mota, A. J., "*Renascido a 24 de Abril?*" Serra da Estrela, Covilhã, Portugal, 2003.
[5] Jarvis, S. and D. Harris, *"Looking for an accident: glider pilots' visual management and potentially dangerous final turns"*, Aviation Space and Environmental Medicine, 2007.
[6] Knueppel, J., "*Gliding Aviation Medicine, High Altitude Aspects and Mountain Wave Project 1999*", St. Martin de los Andes, Argentina, 2000.
[7] Knueppel, J., "*Practical Preventive Measures and Treatment of DCS (Decompression Sickness) in High Altitude - Glider Flying above 22.000 ft / 6.000 m*"; German Aeroclub (DaeC), DGLRM, DFV, ASMA, 1998.
[8] Perlan Project, http://www.perlanproject.com/, Available: 30/05/2010.
[9] Google maps, http://maps.google.com/, Available: 30/05/2010.
[10] Kochanowski, M., (particular collection of photos), Covilhã, Portugal, 2010.
[11] Pelicano, http://www.pelicano.com.pt/zp_covilha.html, Available: 30/05/2010.
[12]AABCO Medical,http://www.aabcomedical.net/cat/respiratory/images/IRC700_400_A.jpg, Available: 30/05/2010.

Anexo V

Artigo Científico a submeter para publicação em revista científica ISI

GLIDING IN ALTITUDE AND NEAR THE MOUNTAINS

PHYSIOLOGICAL EFFECTS AND GLIDER PILOT'S PERFORMANCE

Ana Fonseca and Jorge Silva
Aerospace Sciences Department
Beira Interior University, Covilhã, Portugal
+ 351 275 329 732; + 351 275 329 768
ana_b_fonseca@hotmail.com and jmiguel@ubi.pt

ABSTRACT

Flying in general, and gliding (soaring) in particular, requires high levels of concentration which may be affected by physiological symptoms of the pilot. This is mainly relevant if the glider activity is developed near natural obstacles as, for example, the mountains.

Flying all around mountains, i.e., in altitude, means quite always the danger of oxygen deprivation, mainly if the pilots have no time enough to feel, or recognize, the symptoms of hypoxia, which may affect their performance augmenting therefore the probability of an accident.

The purpose of this work is to study the linkage between physiological effects and glider pilot's performance, mainly when flights are in altitude and near mountains, where to know in advantage those effects may be crucial to ensure the safety of flights.

We developed this work at Covilhã, near Serra da Estrela, where there are both very good conditions for gliding (soaring) and a growing community of glider pilots. Following some recommendations from the state of the art review we installed aboard medical equipment and video cameras to determine precisely the correlation between physiological parameters and flight performance of pilots.

Key words: Physiological Effects, Pilot's Performance, Gliding Activity in Altitude near Mountains

1. INTRODUCTION

The Federal Aviation Administration (FAA) defines a glider as a heavier-than-air aircraft that is supported in flight by the dynamic reaction of the air against its lifting surfaces, and whose free flight does not depend on an engine [1].

To remain in the air for quite some time gliders require rising air to help them climb because otherwise after release the towable aircraft they start fallen to the ground due to gravity. Thus, there are three classic ways to fly without engine:

- Thermal soaring (Figure 1);
- Slope or ridge soaring (Figure 2);
- Wave soaring (Figure 3).

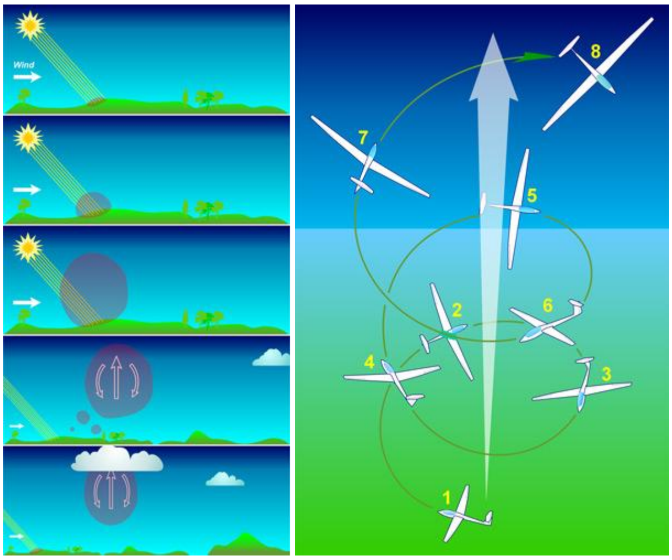


Figure 1: Thermal soaring [1]

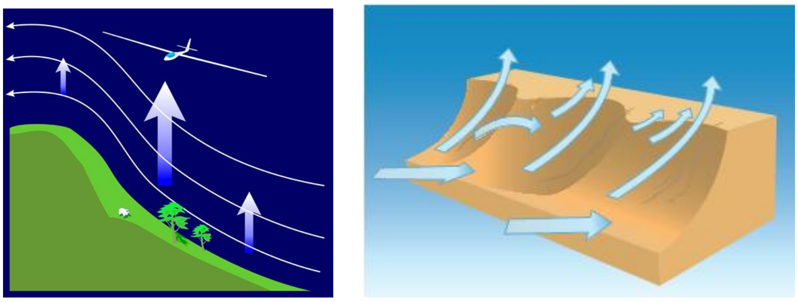


Figure 2: Slope or ridge soaring [1]

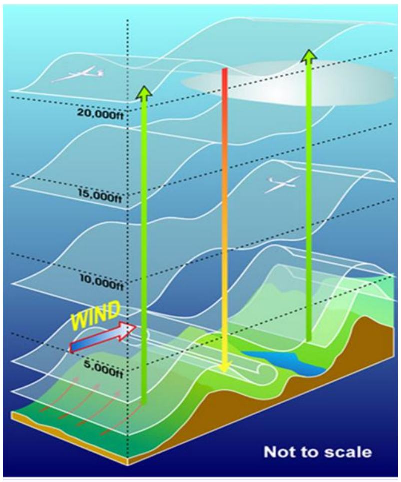


Figure 3: Wave soaring [1]

In Portugal there are no currently many pilots practicing gliding but is now starting to notice a growing interest in this activity. In the case of the zone of Serra da Estrela in general and in particular of Covilhã, there are conditions to fly both in thermal soaring and in slope or ridge soaring or in wave soaring, as we shall see in due course.

Despite all the developments in technology to improve safety flight there is a factor that remains the same - the human factor. Through a broader perspective, the term "human factor" describes the cause of some accidents / incidents, but usually they occur not only due to a single decision or event but rather due to a chain of events triggered by a number of factors (Figure 4).

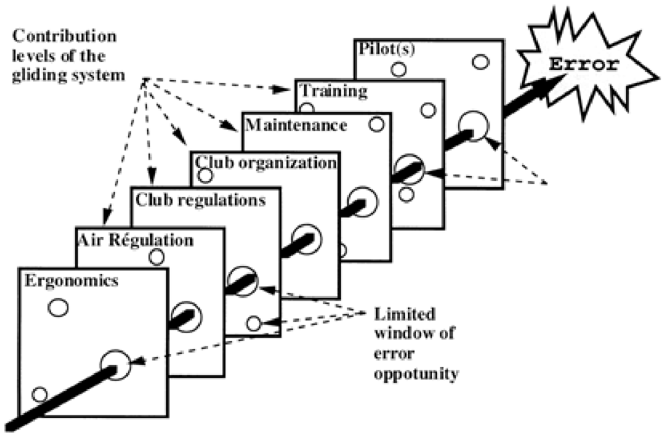


Figure 4: The model of James Reason [2]

It has been estimated that 65% of accidents involving gliders were due to human factors. Thus, it can be concluded that fly in general and gliding in particular, requires intense concentration and responsibility.

A number of physiological effects can be linked to flying. Some are minor, while others are important enough to require special attention to ensure safety of flight. In some cases, physiological factors can lead to in-flight emergencies. Some important medical factors that can affect glider pilot are: hypoxia, hyperventilation, middle ear and sinus problems, spatial disorientation, motion sickness, carbon monoxide poisoning, stress and fatigue, dehydration and heatstroke, alcohol and drugs, and decompression sickness [1]. For example, the medical factor Hypoxia occurs when there is an inadequate supply of oxygen necessary for normal functioning of the human body. The forms of hypoxia can be divided into four different groups based on their cause, that is: hypoxic hypoxia (due to the reduced partial pressure of oxygen at altitude); hypemic hypoxia (when the blood is not able to carry a sufficient amount of oxygen to the cells of the body due to, for example, situations of anemia, blood loss due to a donation, or by carbon monoxide poisoning); stagnant hypoxia (poor blood circulation caused by, for example, a heart problem, a shock or a blocked artery, or may also be the result of many G's positive or low temperatures that result in the reduction of blood flow and difficulty of irrigation of the extremities of the body); and histotoxic hypoxia (inability of the cells to effectively use oxygen. This impairment of cellular respiration can be caused by alcohol and other drugs, such as narcotics and poisons). The symptoms of hypoxia vary with the individual but the common symptoms are:

- Headache;
- Decreased Reaction Time;
- Impaired Judgment;
- Euphoria;
- Visual Impairment;
- Drowsiness;
- Lightheaded or Dizzy Sensation;
- Tingling in Fingers and Toes;
- Numbness;
- Blue Fingernails and Lips (Cyanosis);
- Limp Muscles.

2. LITERATURE REVIEW

Currently, although the gliding is already a category for recreational aircraft ancient, many studies haven’t yet been carried out taking into consideration the safety of the pilots. In Portugal, only in military aviation is given enough importance to the medical factors; in civil aviation only during the course of the pilot is taught, on some hours of lectures, the medical factors that can implicate the safety but in practice there isn’t any specific training. Thus, and as the currently community of civilian pilots has been increasing (flying for leisure mainly at weekends), we think it is extremely important to study the conditions under which the sport is practiced and raise awareness among the pilots about the safety associated with it.

Some of the articles studied in the beginning of the study were the follows:

- ✓ “*Glider accidents in France from 1989 to 1993: the role of the pilot*” [2]

  The purpose of this paper is to give a picture of glider accidents in France from 1989-1993: 255 typical accidents were analysed in the light of recent developments in cognitive psychology. It is shown how Human Factors in aeronautics can explain glider accidents: each accident is considered as an event resulting from an error linked to a cognitive process, frequently linked to particular causes. 255 criteria (type of flight, injuries, damage, pilot experience, type of errors, etc.) are compared as causal factors of the accident. Several suggestions are made with the hope of increasing the safety of soaring flight.

- ✓ “*Algumas notas sobre o voo de montanha – o testemunho de um neófito.*” [3]

  António Vieira Conde wrote this article after doing mountain flights in Covilhã in double command with José Aguiar. According to him, the basic rules of flying with safety are as follows:
  - You can not fly in the mountains for "attitude" (as opposed to what happens in the plain), because there is no horizon line as a reference;
  - The pilot must be always aware of the wind direction because the wind direction at the surface is not necessarily what is observed at high altitude;
  - The pilot should never go to the other side of the ridge of the mountain where it flying because going there without a security height it could lead to being "sucked" by a descendant;
  - The technique of in-flight climb mountain advises that one must fly along the ridge of the mountain enjoying the ascendant;
  - In the Serra da Estrela, on the side of the hill which is facing the east (Covilhã), the flight must be done by "levels" / "steps", whose security height depends on the wind and the turbulence. In this area we find three levels of progression: 1º- “Varanda dos Carquejais / Sanatório”, 2º- “Penhas da Saúde / Lago Viriato”, e 3º- “Torre”.

- ✓ “*Renascido a 24 de Abril?*” [4]

  António Mota reported in the 1st person an accident on he was victim. The accident was on 4/24/2003 on the mountain (Serra da Estrela). The glider on he was flying was a PW5 (CS-PBN / "C3") which become totally destroyed but fortunately it only resulted in minor abrasions to him.

According to António Mota dangers of gliding are on all sides! Thinks so basically due to two factors. There are dangers in just three classical forms of glide and because it happens in Portugal (as in many other countries) that in *PP ab-initio* courses the pilots are only trained to fly in thermal soaring.
In case of the accident that he was involved, António Mota, decided to try to fly alone in slope or ridge soaring despite their 150 hours of experience in flying gliders were all in thermal flight.

- ✓ "*Looking for an accident: glider pilots' visual management and potentially dangerous final turns.*" [5]

  Accidents caused by spinning from low turns continue to kill glider pilots despite the introduction of specific exercises aimed at increasing pilot awareness and recognition of this issue. In-cockpit video cameras were used to analyze flying accuracy and log the areas of visual interest of 36 qualified glider pilots performing final turns in a training glider. Pilots were found to divide their attention between four areas of interest: the view directly ahead; the landing area (right); the airspeed indicator; and an area between the direct ahead view and the landing area. The mean fixation rate was 85 shifts per minute. Significant correlations were found between over-use of rudder and a lack of attention to the view ahead, as well as between the overall fixation rate and poorer coordination in the turn. The results provide some evidence that a relationship exists between pilots' visual management and making turns in a potentially dangerous manner. Pilots who monitor the view ahead for reasonable periods during the final turn while not allowing their scan to become over-busy are those who are most likely to prevent a potential spin.

- ✓ "*Gliding Aviation Medicine, High Altitude Aspects and Mountain Wave Project 1999*" [6]

  Mountain Wave Project 99, in Argentina, was a scientific Hi-Tec first time high altitude wave glider-flying excursion. To make the study two groups of about 15 experienced pilots (accompanied by three high performance motor-gliders: a two-seat Stemme SV 10, an ASH 25 M and a Nimbus 4M), supported by the Argentine pilots, performed more than 100 flights, totaling hundreds of flight hours and sometimes over long distances of more than 1800 kilometers, setting some world records. In this project were involved several areas of knowledge and between these, medical factors were one of the most demanding. In summary, some of the tasks undertaken in this project were:
  - Flying at altitudes above 3,000 meters (10,000 feet) in gliders requires special attention to medical factors such as, for example, hypoxia;
  - Wave Flying at altitudes above 6000 m / 20 000 ft requires special high altitude preparations;
  - High altitude scientific literature studies, basic instruction and hypobaric chamber training were performed;
  - Technical planning, O_2 requirement calculation and emergency training had to be done;
  - Were tested and used two systems of oxygen supply to pilots (EDS & Bendix) because at altitudes below the EDS oxygen system provides enough O_2, but the functionality of the battery must be monitored closely;

- Hypothermia, Hypoxia, Hyperventilation and DCS (Decompression Sickness) are the physiological threats.
The flight safety and altitude physiology rules were known due to prior intensive basic training and thus all flight safety related concepts were key elements for the success of MWP 99.

✓ "*Practical Preventive Measures and Treatment of DCS (Decompression Sickness) in High Altitude - Glider Flying above 22.000 ft / 6.000 m*" [7]

According to Juergen Knueppel, the glider pilots who fly above 20,000 feet (6,000 m) should know the basics of the Law of the Henry gas, in order to be prepared to fight the decompression sickness (DCS). Scientific knowledge is still in development, however, at the outset several empirical limits must be respected to avoid possible disastrous consequences for health (including the death of pilots). Decompression sickness leads to the formation of nitrogen bubbles in the human body, and there are two main types of symptoms of DCS that should be differentiated:
- Type I: Symptoms are mainly severe pain in joints, leading to the pilot to fold onto itself;
- Type II: The symptoms are neurological in nature such as the brain and nerve dysfunction. Such symptoms are considered serious.
The first-aid after the first symptoms of decompression sickness are: Apply 100% oxygen; hydrate by drinking isotonic solutions (water with ⅓ of apple juice and / or ½ teaspoon of salt) and take the patient into a hyperbaric chamber for 2-5 hours. According to Juergen Knueppel a rule to follow is that no pilot shall perform any flight the next day to perform a high altitude where they had occurred and symptoms of DCS.

✓ "*The Perlan Project*" [8]

The Perlan project is divided into three phases:
- Phase 1 consists in soaring to the stratosphere using mountain wave and the Polar Vortex. A glider (DG505M) was used to do this phase and the pilot used full pressure suits because the cockpit of this glider is unpressurized.
In Omarama (New Zealand) and El Calafate (Argentina), on August 30th, 2006, with the pilots Steve Fossett and Einar Enevoldson was set a world-record altitude for gliders of 50,671 feet (15,447 m). Measurements taken during the flight proved that they had reached the stratosphere. This has provided the team with valuable information that will be used in Phase 2;
- Phase 2 consists to soar to 90,000 feet using stratospheric mountain waves and the Polar Vortex. This phase requires a special pressurized high altitude glider to be built. The location will be where the previous record was set (El Calafate, Argentina). This phase will be on August-September 2011;
- Phase 3 have the goal to soar to 100,000 feet and carry out long international flights using the Polar Vortex. The location, the time and the glider is still undetermined.

✓ "*Acute hypoxia and related symptoms on mild exertion at simulated altitudes below 3048 m.*" [9]

Helicopter aircrew have reported features of hypoxia below 3,048 m (10,000 ft). The aim of this study was to examine the effect of physical activity below 3,048 m on the development of hypoxia. The study was conducted using the hypobaric chamber located at the Armed Forces Aeromedical Centre (AFAMC), Saudi Arabia. The study was done at sea level, at 610 m, 2,134 m, and 2,743 m (2,000 ft, 7,000 ft, and 9,000 ft). There was an abrupt decrease in SpO_2 once physical activity began as shown in the Figure 5. It was small at sea level (1%) and at 610 m (2.2%), however, the SpO_2 fell by 4.3% at 2,134 m and 5.5% at 2,743 m (to SpO_2 88.1% and 85.7%, respectively). SpO_2 returned to near-resting values within 3 min of stopping exercise. Symptoms of hypoxia were reported significantly more frequently during activity than rest at each of the altitudes. Thus, helicopter aircrew should be aware that physical activity as low as 2,134 m can produce hypoxemia and symptoms of hypoxia similar to that which would normally be expected in a person resting at approximately 3,658 - 4,572 m (12,000-15,000 ft).

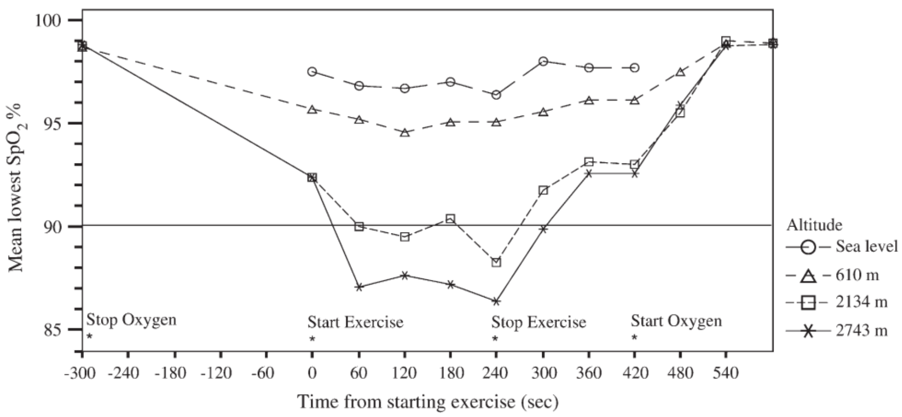


Figure 5: SpO_2 related to physical activity at increasing altitude.
The line through SpO_2 90% approximates a typical person resting at 3048 m.

✓ "*Glider accidents: an analysis of 143cases, 2001 – 2005.*" [10]

Although gliding has gained popularity in recent decades, we could find no systematic analysis of glider accidents. This study determined factors associated with both non-fatal and fatal glider accidents to document their position within sport and general aviation accidents, and to suggest preventive measures and improvements. So, it was performed a retrospective review of glider accidents for the period 2001-2005 in the database maintained by the U.S. National Transportation Safety Board (NTSB). The results obtained were a total of 117 non-fatal and 26 fatal glider accidents reported for the 5 year period (Table 1). Adverse weather was the cause in 20% of all non-fatal accidents, 60% of which occurred in the cruise phase (Table 2). Logistic regression revealed that fatal accidents were predicted by pilot error, flight phase, and home-built aircraft. Thus, owners of home-built gliders should pay particular attention to the aircraft's specifications and design limits.

	Injury Severity					
	Non-Fatal		Fatal		Total	
Flight Phase	N	%	N	%	N	%
Assembly	3	2.1	0	0.0	3	2.1
Tow	18	12.6	3	2.1	21	14.7
Cruise	28	19.6	16	11.2	44	30.8
Landing	68	47.6	7	4.9	75	52.4
Total	117	81.8	26	18.2	143	100.0

Table 1: Number of glider accidents and percentages as a function of flight phase and injury severity.

	Injury Severity					
	Non-Fatal		Fatal		Total	
Cause	N	%	N	%	N	%
Pilot	89	62.2	25	17.5	114	79.7
Weather	20	14.0	0	0.0	20	14.0
Malfunction	6	4.2	1	0.7	7	4.9
Undetermined	2	1.4	0	0.0	2	1.4
Total	117	81.8	26	18.2	143	100.0

Table 2: Number of glider accidents and percentages as a function of NTSB designated cause and injury severity.

- ✓ "*Pulse oximetry: basic principles and applications in aerospace medicine.*" [11]

  "Pulse oximeters are reliable, objective, and non-invasive monitors that have broad application in aerospace medicine. New technology enables pulse oximeters to perform well in adverse environments and measure additional parameters. Small, battery-powered devices can be used to monitor oxyhemoglobin saturation while in flight. Pulse oximeters use spectrophotometry to measure the ratio of oxyhemoglobin (HbO_2) to reduced hemoglobin (Hb) in arterial blood. This value is displayed as oxyhemoglobin saturation (SpO_2). Accurate determination of oxygen saturation requires a high quality arterial signal and is limited by errors resulting from calibration, motion and vibration. Conventional fingertip probes may interfere with the performance of required duties, while helmets and other restrictive clothing can impede the use of sensors on the forehead or ear. Recently introduced devices answer some of these limitations and enable measurement of additional parameters. For example, new probe designs permit more freedom of movement and include a contactless camera and a sensor that fits around a finger like an ordinary ring. This article explains the theory of operation and limitations of pulse oximetry, offers an update on new technology, and discusses applications of this technology in aerospace medicine."

- ✓ "*Estatísticas 2009 – GPIAA (Gabinete de Prevenção de Acidentes com Aeronaves).*" [12]

  The GPIAA present each year on its website (http://www.gpiaa.gov.pt), statistics of accidents and incidents involving civil aircraft occurred on the national territory and also the national aircraft accidents occurring abroad. The period considered in this article covers the last six years reflecting thus a comparative statistical analysis of the period between 2004 and 2009. In this period (2004 to 2009), preceded to the investigation 177 accidents and incidents. We can see through the Figure 6 the annual distribution of these accidents. Table 3 shows the movements in the air traffic management recorded in the Flight Information Regions of Lisbon and Santa Maria between 2004 and 2009 (data provided by NAV Portugal EPE to GPIAA).

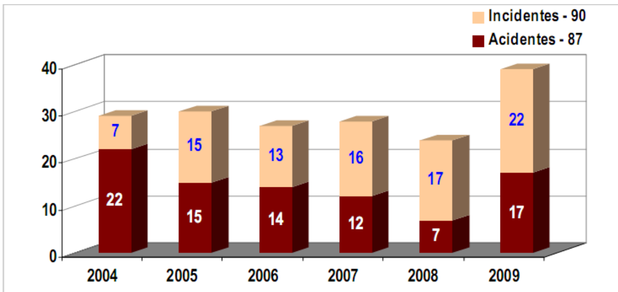


Figure 6: The annual distribution of accidents between 2004 and 2009

ANO	2004	2005	2006	2007	2008	2009
Total de movimentos	479 181	497 820	524 679	558 626	576 603	546 000
Tráfego *IFR*	444 231	461 761	490 176	520 662	535 995	503 514
Tráfego *VFR*	34 950	36 059	34 503	37 964	40 608	42 486

Table 3: Number of movements in the air traffic management recorded in the Flight Information Regions of Lisbon and Santa Maria

Analyzing accidents occurring between 2004 and 2009, spread across every sector of civil aviation (Figure 7), the General Aviation and Ultra-light aircraft Motorized (ULM) stand out negatively with 52 accidents, which include the 19 accidents with only Ultra-lights aircrafts. Mark out the ULM, General Aviation activity has a major expansion in air combining so many supporters, and therefore deserving an individualized study.

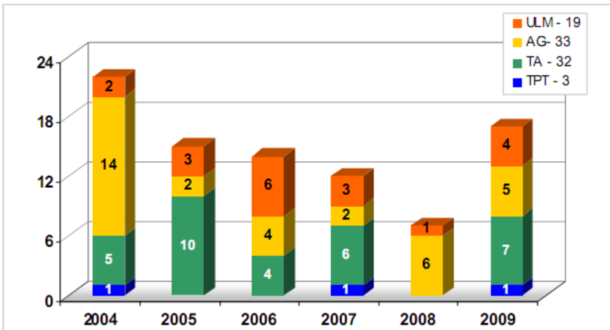


Figure 7: Accidents per air activity

After all, according to the report of GPIAA in 2009 the frequency of fatalities involving ULM shows a decreasing phase. AG means any other air activity not mentioned in TA and TPT groups. Including the activities of the Aero Clubs and private aircrafts, ULM's, helicopters, gliders, balloons or blimps. They are not considered for the purposes of the investigation, the accidents with parachuting, paragliding or hang gliding without engine. TA (Air Work) - includes all activities of airplanes, helicopters, balloons or dirigibles, made by companies or

for-profit entities and duly authorized to exercise such activities as agriculture, aerial photography, INEM (*Instituto Nacional de Emergência Médica*) service, or SNBPC (*Serviço Nacional de Bombeiros e Protecção Civil*), search and rescue, surveillance, patrolling, tow sleeve advertising, riding instruction, etc.. TPT (Air Transportation) - includes regular and non-regular transportation of passengers, cargo and mail on aircraft or helicopters and for profit.
Finally, the GPIAA concludes that accidents occur mostly at the stages of approach and landing (Figure 8).

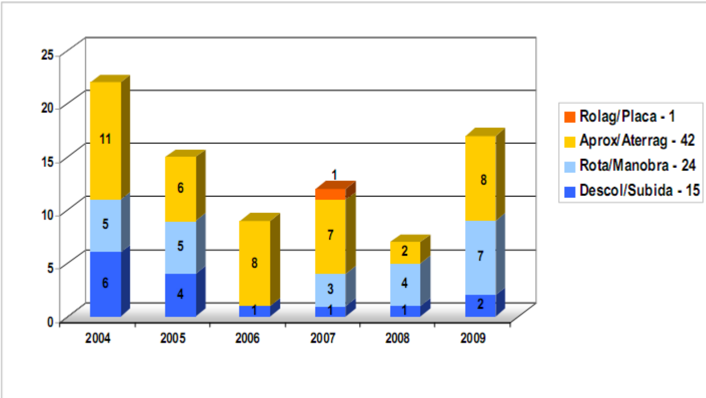


Figure 8: Accidents per flight phases

3. GLIDING AROUND COVILHÃ

As we can see in Figures 9-11, the area of Covilhã, has excellent weather and topographical conditions that allow gliding. As we can see in Figure 11 the prevailing wind in this region facilitates the formation of updrafts that will enable the three classical forms of soaring (in thermal, slope or ridge and in wave).

Figure 9: Map with the location (A) of Covilhã [13]

Figure 10: Topography of the region of Covilhã and Serra da Estrela [13]

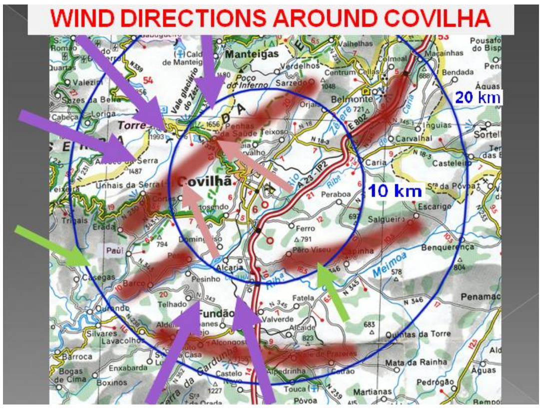


Figure 11: Wind directions around the region of Covilhã
(curves in red = mountain areas) [14]

Moreover, it is also possible to check through the images of clouds of Figures 12 and 13, the likelihood of rising air in the region of Covilhã is high.

Figure 12: *Lenticular* clouds in Covilhã [14]

Figure 13: *Cumulus* clouds in Covilhã [14]

Besides the good weather that Covilhã have for the practice of gliding, this city also has an aerodrome (Figure 14) with two runways from which are now becoming increasingly towed gliders during the weekends. As well as air traffic in the region is very small it can be concluded that this is a "good bet" for the development and growth of the practice of gliding in Portugal!

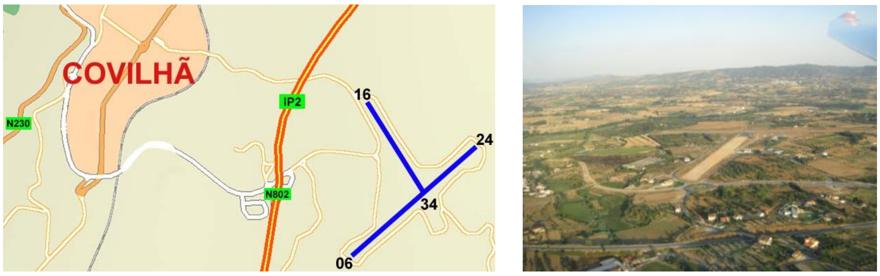


Figure 14: Covilhã Airfield (LPCV) [15, 16]

4. CASE STUDY

Since Covilhã is one of the major places of interest for gliding in Portugal (due to, among other things, the excellent topographical conditions), it is important to study the physiological factors in gliders pilots for each pilot may know their own physical limits when flying at altitudes higher than those obtained in thermal soaring. The study we develop was intended to understand the symptoms of lack of oxygen in the blood (hypoxia) during flight in gliders. We know in theory that hypoxia causes: headache, decreased of the reaction time, euphoria, etc., and with this study we wanted to evaluate if in real time these symptoms will affect the performance of the glider pilots in flight in the region of Covilhã.

To reach this we installed on board of a glider some medical equipment (like the one showed on the Figure 15) gently provided by GASIN.


Figure 15: Pulse Oximeter [16]

The glider used for this study was a Duo Discus. A photo of this glider and some specifications are shown in Figure 16 and in Table 4.


Figure 16: Glider Duo Discus [16]

Span	20 m	65.62 ft
Wing área	16,4 m^2	176.53 ft^2
Aspect ratio	24,4	24.4
Empty weight	410 Kg	904 lb
Maximum all-up mass	750 Kg	1654 lb
Wing loading	29,3 – 45,7 Kg/m^2	6.0 – 9.4 lb/ft^2
Max. permitted speed	263 Km/h	142 kt (163 mph)
Maximum L/D approx	46 - 47	46 - 47

Table 4: Technical specifications of a Duo Discus XL[1] Glider [17]

One of the flight tests were done on 7th August 2010. At about 16h00 we flew from Covilhã Airfield (LPCV) and stood on air at high altitude (10,000 ft) for more than 3 hours. The results obtained were compared with those of the pilot but obtained at his local of residence, thus acting as a reference level. Figures 17 and 18 show the most relevant results.

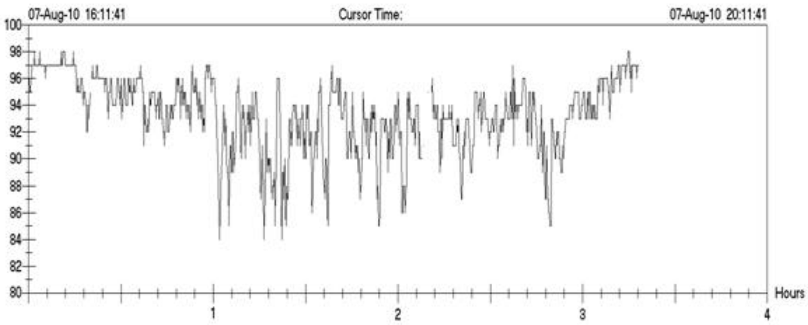


Figure 17: Results obtained on board of a Glider at about 3,000 m [18]

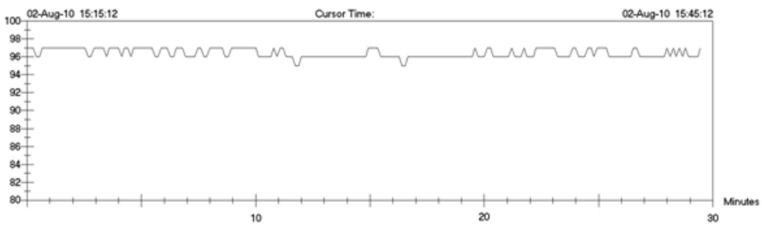


Figure 18: Results obtained at the local of pilot residence [18]

Figures 17 and 18 show that when the pilot began to fly over the mountain (around 16h25m) the levels of SpO_2 soon began to drop to values of 92%. Almost through the flight, as the pilot continued to fly even higher altitudes (10,000 ft ≈ 3,050 m), the levels of oximetry decreased even more sharply to 84%. The variability was quite large, i.e., while in the reference values measured in the ground (Figure 18) the values of SpO_2 levels varied only between 95% and 97% (and quite all the time between 96% and 97%), at higher altitude as shown in Figure 17 these varied between 84% and 97%. At the end of the flight when the glider started to descend and subsequently landing the recovery was relatively quick and the oximetry levels were again similar to the initial values, reaching 98% of SpO_2.

---

[1] The difference between a Duo Discus XL and a Duo Discus is that the first one is equipped with winglets.

The maximum altitude attained during our flight was 10,000 feet (3,050 m). Despite only being advised to take preventive measures above this altitude, we determined that the pilot experienced some symptoms of hypoxia, referred in chapter 2.

The medical factor of hypoxia has the four stages indicated in Table 5 and the results obtained by us during the flight testes although they did not fit in a critical phase are not completely meaningless / indifferent.

Stage	Altitude in feet		Arterial oxygen saturation (%)
	Breathing air	Breathing 100% O_2	
Indifferent	0 – 10.000	33.000 – 39.000	95 – 90
Compensatory	10.000 – 15.000	39.000 – 42.000	90 – 80
Disturbance	15.000 – 20.000	42.200 – 45.200	80 – 70
Critical	20.000 – 23.000	45.200 – 46.800	70 – 60

Table 5: Stages of hypoxia [19]

In healthy people the second stage (compensatory) may come at altitudes between 10,000 and 15,000 feet because the human body in general has the ability to react to the effects of hypoxia, increasing the frequency and depth of the ventilation and the cardiac output. Although, this not always happen.

The results we obtained during the flight in the glider fall within the second stage (compensatory) despite having been made at lower altitudes than indicated in Table 5.

5. CONCLUSIONS / FUTURE CHALLENGES

Symptoms of hypoxia are slow but progressive and are more significant from altitudes above 10,000 feet (3,050 m). Smokers, for example, may experience symptoms of hypoxia at lower altitudes than non-smokers. Moreover, the results of this study showed values that are already considered to hypoxia even below 10,000 feet (3,050 m) and in non-smoking drivers.

With this work the initial objectives have been achieved despite not having had the gliders available as we would wish due to several factors. Also the medical equipment for recording oximetry has proved not to be the more appropriate because during the work were lost some record in flight due to sensors used do not work very well with humidity.

We consider it important to place on board of the gliders instruments that allow the pilot to continuously monitor some parameters of their physiological state.

In the near future there should be legislation more strict and controlling in medical terms for the case of civilian pilots in *sports classes*.

We also consider very important evaluate other variables that contribute to the hypoxia, that not only the variation of oxygen in the blood as it was monitored.

Tests carried out by us confirmed the importance of the phenomenon of hypoxia and, therefore, it is necessary to seek solutions that can reduce, or eliminate, in real time, the dangers of this medical factor on the operational performance of pilots in general, and in the gliders in particular.

REFERENCES

[1] Federal Aviation Administration (2003) *Glider Flying Handbook.* New York, Aviation Supplies and Academics Inc.

[2] Caron, F. (1997) *Glider accidents in France from 1989 to 1993: the role of the pilot*, Paris, France, Université René Descartes.

[3] Conde, A. V. (2009) *Algumas notas sobre o voo de montanha - o testemunho de um neófito*, Covilhã, Portugal.

[4] Mota, A. J. (2003) *Renascido a 24 de Abril?* Serra da Estrela, Covilhã, Portugal.

[5] Jarvis, S. and Harris, D. (2007) *Looking for an accident: glider pilots' visual management and potentially dangerous final turns*, Aviation Space and Environmental Medicine.

[6] Knueppel, J. (2000) *Gliding Aviation Medicine, High Altitude Aspects and Mountain Wave Project 1999*, St. Martin de los Andes, Argentina.

[7] Knueppel, J. (1998) *Practical Preventive Measures and Treatment of DCS in High Altitude - Glider Flying above 22.000 ft / 6.000 m*, German Aeroclub (DaeC), DGLRM, DFV, ASMA (Aviation Space and Environmental Medicine).

[8] The Perlan Project (2010), http://www.perlanproject.com/ (Available: 17/10/2010).

[9] PubMed (2010) *Acute hypoxia and related symptoms on mild exertion at simulated altitudes below 3048m*, http://www.ncbi.nlm.nih.gov/pubmed/17955948 (Available: 17/10/2010).

[10] IngentaConnect (2010) *Glider accidents: an analysis of 143 cases, 2001 – 2005*, http://www.ingentaconnect.com/content/asma/asem/2007/00000078/00000001/art00005 (Available: 17/10/2010).

[11] PubMed (2010) *Pulse oximetry: basic principles and applications in aerospace medicine*, http://www.ncbi.nlm.nih.gov/pubmed/17955947 (Available: 17/10/2010).

[12] GPIAA (2010) *Estatísticas 2009*, http://www.gpiaa.gov.pt (Available: 17/10/2010).

[13] Google maps (2010) *Covilhã*, http://maps.google.com/ (Available: 17/10/2010).

[14] Kochanowski, M. (2010) *Gliding around Covilhã*, (particular collection of photos).

[15] Pelicano - Aviação Ultraligeira (2010) *LPCV*, http://www.pelicano.com.pt/zp_covilha.html (Available: 17/10/2010).

[16] Fonseca, A. (2010) *Voo à Vela na Zona da Covilhã*, (particular collection of photos).

[17] Schempp-Hirth Flugzeug-Vertriebs GmbH (2010) *Duo Discus*, Kirchheim/Teck Stuttgart, Germany.

[18] Gasin (2010) *Oximetros*, http://www.gasin.pt/ (Available: 17/10/2010).

[19] Ribeiro, J. (2001) *Fisiologia de Voo - Fisiologia de Voo. Formação AME's / Capítulo 1*, Lisboa, INAC / AMS.